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Emission and Fuel Economy of FUEL-MAX A Retrofit Device

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Emission Control Technology Division
Office of Mobile Source Air Pollution Control
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16. ABSTRACT

This report describes the results of testing the "FUEL-MAX" device as part of an evaluation under Section 511 of the Motor Vehicle Information and Cost Savings Act. The FUEL-MAX is an air-bleed device which replaces a vehicle's Exhaust Gas Recirculation (EGR) valve. The amount of air bled into the intake manifold is determined by the vacuum signal which once controlled the action of the EGR valve. This device is claimed to conserve fuel. The primary purpose of this project was to evaluate the effect of the FUEL-MAX on exhaust emissions and fuel economy.

Testing of three typical 1979 model year passenger cars was conducted during March, 1981. The basic test sequence included the Federal Test Procedure (FTP) and the Highway Fuel Economy Test (HFET). These tests were performed both before and after installation of the FUEL-MAX. As a result of the testing, average hydrocarbon and carbon monoxide emissions decreased somewhat while oxides of nitrogen displayed substantial increases. Fuel economy was found to increase approximately three percent on the FTP but exhibited no change over the HFET. The occurrence of engine knock was obvious on two of three vehicles. EPA's Office of Enforcement has determined that the FUEL-MAX can violate the anti-tampering provisions of the Clean Air Act.

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Abstract

This report describes the results of testing the "FUEL-MAX" device as part of an evaluation under Section 511 of the Motor Vehicle Information and Cost Savings Act. The FUEL-MAX is an air-bleed device which replaces a vehicle's Exhaust Gas Recirculation (EGR) valve. The amount of air bled into the intake manifold is determined by the vacuum signal which once controlled the action of the EGR valve. This device is claimed to conserve fuel. The primary purpose of this project was to evaluate the effect of the FUEL-MAX on exhaust emissions and fuel economy.

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Background

Section 511 of the Motor Vehicle Cost Savings and Information Act empowers the Environmental Protection Agency (EPA) to evaluate devices or fuel additives which may improve the fuel economy of conventional motor vehicles. The EPA has developed and instituted a procedure whereby an individual or organization may apply for an evaluation of the device or fuel additive. This procedure requires the applicant to submit a technical description of the system in conjunction with results from actual testing. Once a complete application is received, the EPA will conduct an engineering evaluation and publish the results in the Federal Register. In those cases where the device or additive shows promise, the EPA will conduct tests as a part of its evaluation. Such testing is performed at EPA's Motor Vehicle Emission Laboratory in Ann Arbor.

In February, 1980, EPA received an application from Fuel Injection Development Corporation for an evaluation of the FUEL-MAX. This device is an air-bleed mechanism which replaces the Exhaust Gas Recirculation (EGR) valve. The amount of air bled into the intake manifold is determined by the vacuum signal which once controlled the action of the EGR valve.

Based on an evaluation of the test results submitted to support the claims for the FUEL-MAX, EPA chose to conduct confirmatory testing. The basic purpose of the testing was to determine the effect of the device on fuel economy and exhaust emissions. Secondary purposes included an evaluation of the installation instructions and driveability factors.

Test Vehicles

Three typical 1979 production vehicles were used: a Ford Pinto with a 4-cylinder engine, an Oldsmobile Cutlass with a 6 cylinder engine, and a Mercury Zephyr with an 8 cylinder engine. All vehicles were equipped with automatic transmissions. A more detailed description of each vehicle is provided in Appendix A.

Test Fuel

Commercial, unleaded regular fuel was used in the testing of the FUEL-MAX. A single batch of the fuel was purchased and stored at the EPA. The motor octane number was 83 while the research octane number was 91. The decision to use a commercial fuel was based upon the knock sensitivity of some engines to EGR deactivation. The Indolene fuel used in EPA testing has a higher octane rating than typical commercial unleaded gasoline. Thus, use of commercial fuel was appropriate for this evaluation where the possibility of increased knock was probable.

Type of Tests

Exhaust emission tests were conducted according to the 1977 Federal Test Procedure (FTP) described in the Federal Register of June 28, 1977, and the EPA Highway Fuel Economy Test (HFET) described in the Federal Register of September 10, 1976. The vehicles were not tested for evaporative emissions.

Other tests were also conducted as an additional aspect of this evaluation. These tests consisted of hot start LA-4 cycles. The LA-4 driving cycle is the basic FTP driving cycle. The results of these hot start LA-4 tests are generally similar to bags 2 and 3 of the FTP.

Device Installation

Installation of the FUEL-MAX on the test vehicles was performed in accordance with the device installation instructions. Following installation, a dial on the FUEL-MAX was set for the size of the engine as specified in the instructions; i.e., set at 1.4 for the Pinto (140 CID), 2.3 for the Cutlass (231 CID), and 3.0 for the Zephyr (302 CID).

The following problems were experienced during the installations:

1. On the Pinto, the installation instructions call for the EGR valve to be disconnected from the intake manifold, but to be left connected to the exhaust gas transfer pipe so as to close the end of the transfer pipe. On the test vehicle, the EGR valve and the exhaust gas transfer pipe had to be removed because the configuration of the EGR valve was different than that shown in the installation instructions and an exhaust leak occurred.

2. On the Zephyr, the FUEL-MAX caused an exhaust leak at the manifold where the EGR valve is normally installed. A sealing plate and additional gaskets had to be employed to prevent this underhood exhaust leak.

Vehicle Test Configurations

Baseline testing was performed after each vehicle was set to the vehicle manufacturer's tune-up specifications. The second test configuration was with the FUEL-MAX installed in accordance with the installation instructions. A third configuration was employed in testing the Pinto. In this configuration (along with the FUEL-MAX), the ignition was retarded by 5° from specifications. This was done to correct the heavy knock which had been exhibited in the road evaluation.

Test Results

The vehicles were tested during March of 1981. All tests were performed by EPA at its Motor Vehicle Emission Laboratory in Ann Arbor. Table 1 summarizes the results of this testing. Emission levels are listed in grams/mile while fuel economy is shown in miles per gallon. The results of the individual tests on each vehicle are presented in Appendices B, C, and D.

Table 1
Summary of Test Results

		FTP				HFET			
Vehicle	Configuration	HC	CO	NOx	MPG	HC	CO	NOx	MPG
Ford Pinto	Baseline	2.08	26.0	1.35	21.5	.76	5.2	2.38	29.0
	FUEL-MAX	1.58	18.6	6.03	22.4	.61	2.8	6.83	29.3
	Average Change	-24%	-28%	+350%	+4.2%	-20%	-46%	+190%	+1.0%
Oldsmobile Cutlass	Baseline	1.89	21.0	1.55	18.2	.40	4.7	1.56	26.4
	FUEL-MAX	1.46	19.4	7.44	18.5	.23	1.6	8.72	26.4
	Average Change	-23%	-8.0%	+380%	+1.6%	-43%	-66%	+460%	-0-
Mercury Zephyr	Baseline	2.47	25.5	0.67	15.2	.89	2.7	1.17	22.9
	FUEL-MAX	2.08	14.2	7.17	15.7	.83	1.2	9.03	22.8
	Average Change	-16%	-44%	+970%	+3.3%	-7.0%	-5.6%	+670%	-0.4%
Overall Fleet	Baseline	2.15	24.2	1.19	17.9	.68	4.2	1.70	25.8
	FUEL-MAX	1.71	17.4	6.88	18.5	.56	1.8	8.19	25.9
	Average Change	-20%	-28%	+480%	+3.4%	-18%	-57%	+380%	+0.4%

The Pinto exhibited heavy knock during the road evaluation. In this case, the basic timing was retarded 5° and the vehicle was retested. The results are shown in Table 2 below:

Table 2
Summary of Test Results on Pinto with Retarded Timing

		FTP				HFET			
Vehicle	Configuration	HC	CO	NOx	MPG	HC	CO	NOx	MPG
Ford Pinto	Baseline	2.08	26.0	1.35	21.5	.76	5.2	2.38	29.0
	FUEL-MAX	1.58	18.6	6.03	22.4	.61	2.8	6.83	29.3
	FUEL-MAX (-5°)	1.20	18.3	4.46	22.2	.50	2.0	5.24	29.8
	Average Change (from baseline)	-42%	-30%	+230%	+3.3%	-34%	-62%	+120%	+2.8%

On-Road Evaluations and Observations

Pinto: With FUEL-MAX installed, the vehicle exhibited the following knock characteristics;

a) Cold engine, light acceleration - moderate knock
b) Heavy knock on light accelerations or while maintaining speed on a minor grade
c) Under wide-open throttle accelerations to 55 mph, knock did not occur
d) Idle quality was poor (rough) with a warmed-up engine

Ignition timing retard of approximately 5° removed the knock. Vehicle acceleration performance deteriorated.

Cutlass: With FUEL-MAX, this vehicle exhibited stumble and hesitation attributable to a lean air/fuel mixture. Knock (trace) occurred under heavy accelerations, moderate accelerations and light accelerations. Intermittant, light knock occurred under highway cruise conditions with FUEL-MAX.

Zephyr: This vehicle exhibited occasional occurrences of trace knock. When cold, the vehicle exhibited stumble at 20 mph.

Conclusions

As a result of EPA testing of FUEL-MAX on three 1979 passenger cars, the following conclusions were drawn:

1. The installation instructions and the material packaged with the device were not adequate in all cases.

2. Use of the FUEL-MAX resulted in a decrease in hydrocarbon emissions. The average decrease was 20% for the FTP and 18% for the HFET.

3. Carbon monoxide emissions were also reduced; 28% over the FTP and 57% over the HFET.

4. NOx emissions increased substantially; 480% over the FTP and 380% over the HFET.

5. Use of the FUEL-MAX resulted in a three percent increase in fuel economy on the FTP but essentially no change on the HFET.

6. During the road evaluations, FUEL-MAX caused heavy knock on one car, and light knock in another. Knock was rarely noted on the third car.

7. Installation of the FUEL-MAX device is considered "tampering" under the provisions of the Clean Air Act*.

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*"EPA tests showed that the use of this device, on the vehicles tested caused emissions to exceed applicable standards. Thus, the installation of this device by a person in the business of servicing, repairing, selling, leasing, or trading motor vehicles, fleet operators, or new car dealers will be considered in violation of Section 203(a)(3) of the Clean Air Act, the Federal prohibition against tampering with emission control systems. That is, there is currently no reasonable basis for believing that the installation or use of this device will not adversely affect emission performance. This determination does not preclude the use of the FUEL-MAX device on a different vehicle or vehicles than those tested by EPA if Federal Test Procedure tests performed on such vehicles clearly establish that emission performance of those particular vehicles is not adversely affected.

Appendix A

Test Vehicle Descriptions

Make/Model	Ford Pinto	Oldsmobile Cutlass	Mercury Zephyr
Model Year	1979	1979	1979
Type	2 door	2 door	2 door
Vehicle I.D.	9T11Y186165	3R47A9M523280	9E35F621630
Initial Odometer	23540	34880	31760
Engine Type	Spark Ignition	Spark Ignition	Spark Ignition
Configuration	In-line 4	V6	V8
Displacement	140 CID	231 CID	302 CID
Fuel Metering	2V Carburetor	2V Carburetor	2V Carburetor
Fuel Requirement	Unleaded	Unleaded	Unleaded
Transmission	Automatic	Automatic	Automatic
Tires	B78-13	P195/75R14	CR78-14
Inertia Weight	3000	4000	3500
Actual HP @50 mph	10.3	12.0	11.2
Emission Control Systems	EGR Catalyst	EGR Catalyst	EGR Air Pump Catalyst

Appendix B

Test Results - Ford Pinto, 140 CID, 4 Cylinder

Test Date.	Test #	Configuration	Federal Test Procedure HC	CO	NOx	MPG	Highway Fuel Economy Test HC	CO	NOx	MPG
3-3-81	5560	Baseline	2.09	26.1	1.37	21.44				
3-3-81	5561	Baseline					0.74	5.0	2.35	28.87
3-4-81	5562	Baseline	2.06	26.0	1.33	21.56				
3-4-81	5563	Baseline					0.77	5.3	2.40	29.19
3-5-81	5564	FUEL-MAX	1.66	20.2	5.84	22.06				
3-5-81	5565	FUEL-MAX					0.64	3.2	6.57	29.17
3-6-81	5566	FUEL-MAX	1.50	17.0	6.22	22.71				
3-6-81	5567	FUEL-MAX					0.58	2.3	7.08	29.42
3-25-81	5568	Fuel Max (-5°)*	1.00	18.8	4.36	21.97				
3-25-81	5569	Fuel Max (-5°)					0.49	1.9	4.93	29.80
3-26-81	5570	Fuel Max (-5°)	1.41	17.8	4.56	22.48				
3-26-81	5571	Fuel Max (-5°)					0.51	2.1	5.56	29.90

*For this series of tests, the device remained in place but the basic timing was retarded 5° to correct a heavy knock condition.

Appendix C

Test Results - Oldsmobile Cutlass, 231CID, V-6

Test Date.	Test #	Configuration	Federal Test Procedure HC	CO	NOx	MPG	Highway Fuel Economy Test HC	CO	NOx	MPG
3-4-81	6845	Baseline	1.95	22.3	1.56	18.16				
3-4-81	6848	Baseline					0.55	7.1	1.52	26.17
3-5-81	6849	Baseline	1.82	20.3	1.52	18.37				
3-5-81	6850	Baseline					0.43	5.0	1.44	26.61
3-6-81	6851	Baseline	1.90	20.5	1.57	18.16				
3-6-81	6852	Baseline					0.36	4.2	1.58	26.34
3-10-81	6853	FUEL-MAX	1.40	18.9	7.44	18.43				
3-10-81	6854	FUEL-MAX					0.22	1.4	8.57	26.32
3-11-81	6855	FUEL-MAX	1.51	20.0	7.45	18.62				
3-11-81	6856	FUEL-MAX					0.24	1.6	8.76	26.53
3-19-81	8359	Baseline					0.40	4.6	1.61	26.43
3-19-81	8361	Baseline					0.25	2.6	1.63	26.40
3-19-81	6858	FUEL-MAX					0.23	1.9	8.82	26.42
		HOT START LA-4								
3-19-81	8358	Baseline	1.14	13.4	1.50	19.25				
3-19-81	8360	Baseline	1.32	15.1	1.54	19.54				
3-19-81	6857	FUEL-MAX	1.24	16.5	7.90	19.71				
3-19-81	6859	FUEL-MAX	1.37	15.6	7.73	13.06*				

*Fuel economy void - error in CO_2 readings.

Appendix D

Test Results - Mercury Zephyr, 302CID, V-8

Test Date.	Test #	Configuration	Federal Test Procedure HC	CO	NOx	MPG	Highway Fuel Economy Test HC	CO	NOx	MPG
3-3-81	6771	Baseline	2.42	25.2	0.66	15.10				
3-3-81	6772	Baseline					0.94	1.4	1.34	23.08
3-4-81	6773	Baseline	2.42	24.1	0.69	15.25				
3-4-81	6774	Baseline					0.86	3.8	1.07	22.58
3-5-81	6775	Baseline	2.46	23.2	0.71	15.23				
3-5-81	6776	Baseline					0.86	2.8	1.11	23.09
3-10-81	8094	FUEL-MAX	2.05	14.3	7.20	15.72				
3-10-81	8095	FUEL-MAX					0.81	1.2	9.31	22.77
3-11-81	8125	FUEL-MAX	2.12	14.2	7.14	15.72				
3-11-81	8126	FUEL-MAX					0.85	1.1	8.75	22.80
3-18-81	8302	Baseline	2.58	29.5	0.61	15.04				